DOI: https://doi.org/10.3217/978-3-85125-530-0-24

A Digital Museum Infrastructure for Preserving Community Collections from Climate Change

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Abstract. Climate change poses a real and present threat to cultural heritage. Responses to climate change have focussed on strategies for prevention and physical protection. Developments in technology have made possible a new type of virtual museum that actively supports the work of museums and enables the creation of immersive digital exhibits. This paper proposes that it is important to address the role that community museums play in the digital preservation of natural and cultural heritage. It focusses on the contribution of virtual museums and proposes a distributed virtual museum architecture to support digital preservation. The architecture addresses both the need for high quality local interactions that enables preservation and the need for a global infrastructure that makes the results accessible and enables the development of links between communities.

Keywords: digital museums, climate change, immersion, heritage preservation

1 Introduction

Museums are crucial for the survival of heritage of communities, their physical culture as well as aiding in local economies. They provide a focus for regional tourism and are a vehicle for heritage dissemination. Yet museums exist in a changing world and are themselves forever changing. Climate change is creating extreme and variable weather conditions which threaten cultural heritage and the infrastructures that support them globally [1].

In the last few years 3D and 360˚technologies and their associated digital literacies have spread into the mainstream. This means it is possible to create digital representations of objects and landscapes using commodity hardware already in the possession of museums and their communities. Pairing a smart phone, a cheap headset and 360˚images provides an engaging and accessible immersive experience. Digital 3D models can capture the form and texture of real world objects preserving both against damage of the original. Advances in digital literacies and technologies mean virtual museum technology can be used to support and preserve the work of even small and remote museums.

This topic is critical to explore as the threat of climate change to cultural heritage is a rising danger. For example, In March 2017, museums in the Lambayeque region of Peru were damaged due to unseasonal rainfall and floods [2]. Digital preservation will enable future generations to appreciate heritage which can be suddenly lost or damaged. Work on preservation against climate change will also have applications against other dangers such as conflict, vandalism and the routine change that is part of the day to day life of museums.

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The contribution of this work is the design of a virtual museum infrastructure that will enable community museums to digitally preserve their collections in the face of climate change and other hazards.

The rest of this document outlines the context for the work, discusses the preparedness of community museums and identifies design goals for a digital museum infrastructure that will enable these threats to be countered. An architecture is presented which supports both local work and global access and a deployment strategy is outlined.

2 Museums, Preservation and Climate Change

Severe weather conditions provide a threat to landscapes, archaeology, cultural heritage and cultural heritage institutions in many parts of the globe. These threats are made worse by climate change as weather becomes more extreme and unpredictable. As recognized by the United Nations in the Paris Agreement, there is a "need for an effective and progressive response to the urgent threat of climate change on the basis of the best available scientific knowledge." [3] Valuable collections are under both direct and indirect threat of climate change; physical damage related to adverse weather versus collections housed in historic buildings that cannot adapt or be upgraded to prevent damage to objects. [4] Climate change is recognized by the United Nations as a significant threat that requires action to control and to address the effects [1,9]. The threat of climate change to cultural heritage has attracted extensive investigation including documenting the threat posed to World Heritage Sites [2,3,4] and developing policy and guides to manage risks [4,5]. The vulnerabilities of landscapes [6], archaeology, objects [7] and collections all create concern as does the effect on tourism [8].

Museums are institutional stewards of objects and histories that require protection, preservation and context. Community museums may not have the adequate storage and disaster plan in place to record and care for their physical objects and exhibits spaces if physical harm came to their museum. There has also been practical responses by museums to climate change [10,19]. This includes developing physical protection and engaging with the effects through the development of cultural narratives, construction of exhibits and engagement with communities. Museums have been active through the decades in adopting digital trends that could help ensure the permanence of their collection, but creation and access have been intended for computer specialists, not for museum staff. Recent developments in digital literacies as well as the capability of commodity computers and mobile phones promises the potential to create an innovative model of a virtual museum through web browser and apps.Virtual museums have progressed from web based collections of images, specifically-built virtual worlds, for instance Second Life, and moved towards reality based environments, such as Google Arts & Culture. However, environments like the format Google has created are based off static images; letting visitors view inside museums via panoramas using Street View technology. There has been significant interest in digital access to collections [12,13,14] and virtual museums since the emergence of the web [15,16]. There has also been ongoing research into digitization processes and some on its relation to community [20], for example the Scottish Ten project has produced digital representation of world heritage sites [17] and the

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British Museum has digitized significant portions of its collection, hosted on sites such as SketchFab [18].

Immersive and 3D technologies available today supports a more accessible form of immersive visitor online experience using mobile phones and commodity computers, which can meet institutions needs for sustainability and usability. A virtual museum can support both the full processes of content creation, management and presentation as well as enabling emergent aerial, 3D and 360°technologies to be integrated with established media to create engaging cross platform experiences.

The digital domain offers opportunities for protection from climate change however, it has real world limitations. Digitisation of a site, object or an exhibition will not offer any physical protection from damage. Consequently, digital preservation should be part of an overall strategy which both addresses climate change itself and offers what physical protection is possible. However, the 3D digitisation of an objects state if properly archived will be invaluable if the object itself is lost or damged. The digitisation of exhibitions also preserve spatial relationships and narratives. The digital domain offers the advantages that objects and exhibitions can easily be duplicated and transmitted, enabling protection through co-location and enhanced accessibility. The emerging low cost of technologies enables production of aerial, 360°and 3D technologies combined with widespread digital literacies enables community museums to create, manage and disseminate exhibits that can connect them directly with other communities around the globe.

Preservation of a communitys cultural heritage is critical due to quickly changing environments caused by climate change. By generating digital content that can be managed and accessed like a museum, the objects, stories, and digital tours can be visited and studied even if the physical counterpart is no longer accessible. Today digital literacies and technology exist which will enable a virtual museum infrastructure that offers protection against severe climate change to be designed. This process of design will need to be informed by systematic investigation. A goal will be to enable the community to continue digitizing and manage their online collections as well as utilizing the digital media to expand their online presence. However, recent advances in 3D, gaming and 360°technologies have not yet been fully integrated into the virtual museum canon. The role of virtual museums in preservation of cultural heritage [11] and the specific issues that arise when providing digital protection for community collections have not been directly addressed.

3 Community Museums, threats and challenges

Virtual Museums have the potential to ensure that the form of objects destroyed or damaged through climate change or other hazards would remain available in the digital domain. A community museum represents social history of a community often based in a locality. It connects the objects in its collections with the history and life of the community that is part of. In doing so there is the potential for active community participation in the creation of the museum, creation of its collections and curation of its exhibits.

Community museums vary significantly in size and resource. However, their location is often remote and resources modest meaning that they tend to be more

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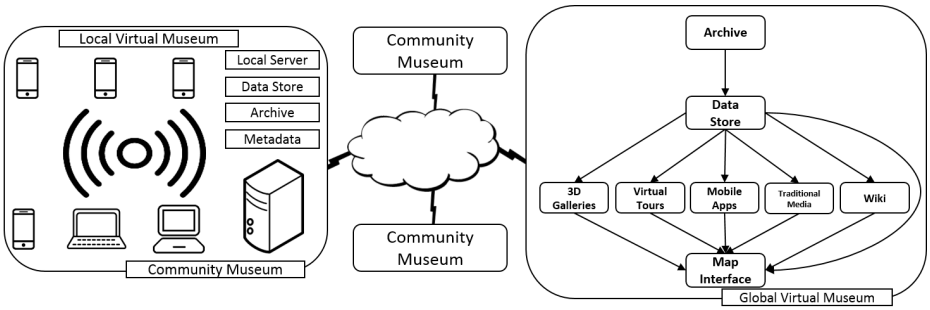

Fig. 1: DMPC4 architecture

vulnerable to the effects of climate change than large subject based museums. The connection to the Internet may be absent, unreliable or slow often ruling out direct use of Internet based digital resources in museum exhibits and exhibitions.

Their engagement with community means they have the potential to both develop and leverage the digital resources and literacies of community members in taking forward the life of the community museum. A focus on defining the cultural heritage of a particular community brings with it the possibility of sharing and connecting with other communities thereby creating direct linkages and mutual understandings that would not be possible through traditional media communications.

The vulnerabilities of community museums, the participation of community and potential for developing understanding through sharing are important factors in deciding on design priorities. Based upon the experience of working with community museums and preliminary research we suggest the need for a design which enables the following requirements to be met:

1. Digital preservation of the state of natural and cultural heritage.
2. Provision of engaging immersive exhibits, accessible locally and globally.
3. Support community participation in the creation and curation of digital heritage.
4. Be affordable through the efficient use of commodity devices.
5. Integrate with existing museum and community digital infrastructures.
6. Connect communities through enabling digital sharing of heritage.

These requirements are in part motivated by the observation that a digital museum for preservation, should integrate explicit preservation activities with a system that supports the day to day activities of a museum. This fits with the conception of an active virtual museum, which encourages participation and contribution by different stakeholders.

4 An Architecture for local needs and global reach

To achieve these goals, a global digital museum for preservation against climate change that connects community museums, provides archive facilities and enables access to immersive exhibits and exhibitions. We propose an architecture (shown in Fig. 1) which consists of a local virtual museum in each community museum and a global component they connect via the Internet.

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Each community museum will have a local system that provides responsive services and connection to the Internet. The local system will be accessible through its own WiFi access point that will enable mobile phones and computers to connect to its resources. It will have local storage that will contain an archive of media and interpretation, described through meta data. Web and app services will support both management of the archive and the presentation of exhibits. A synchronization, upload and download service will support connection to the Internet based global virtual museum. It will enable the reliable exchange of data even when the Community Museum has slow, unreliable or even non-existent Internet connections.

The global virtual museum will consist of the following components. A digital archive will hold resources from all the community museums that are associated with it. Meta data will provide context for the media, enable semantic searches and integration with aggregators such as Europeana. Support for global exhibits and connections with mapping solutions and social archive sites such as Sketchfab for 3D objects and roundme for 360°media will contribute to preservation through promotion.

5 Local Use: Immersion, Interaction and Infrastructure

A local virtual museum will be physically located within each community museum in the network. Local servers will enable resources in the data store to be accessed within the museum and its environs. It will provide the following functionality:

1. Local access to immersive and 3D exhibits on mobile phones or laptops.
2. Support for community engagement in digitization processes.
3. Support that makes it easy for communities to create interpretation and meta data.
4. A searchable archive that holds and organises digital media locally.
5. An integrated WiFi access point to enable access from existing digital infrastructure.
6. Connection with a global archive and peer community museums.

The virtual museum will combines media types through local web interfaces which create a rich and varied experience to users. Users can listen to oral histories (such as folk tales and ancient stories) or be guided around a site using audio narratives, users can undertake virtual tours of remote sites or compare the present and past states of a local site using spherical photos and videos, curators and conservators can combine digital representations of artefacts with interpretation, enabling users to explore and inspect these 3D artefacts remotely using their mobile devices, text snippets can be collectively added by community members to describe entities using an integrated wiki, and the resulting wiki articles are available to consumers to add information and context to their experiences while interacting with said entities.

What would be involved in the digitisation and how would the heritage be digitised? We propose digitising physical museum artefacts using technology already in peoples pockets and inexpensive technologies such as smartphones and digital cameras. Using cameras and free software, 3D replicas of objects can

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be created using photogrammetry, and these 3D artefacts can be disseminated over the Internet, making them accessible on websites and on mobile apps.

Smartphones can be used to capture spherical photos which can be used to make virtual tours. These virtual tours can facilitate remote exploration of sites, and coupled with cheap virtual reality headsets (such as the Google Cardboard), immersive experiences can be provided to users. Audio recordings can be used for preserving oral histories such as stories, folklores and tales, while video recordings can be used for guided tours or as part of remote virtual tours. This digital content will be described and curated using a crowdsourcing approach to metadata creation, such that community members and heritage practitioners alike can contribute to the description of digital entities. A web-based archive form will make it easy to upload meta data which, together represent and describe entities that are presented to users. Data supplied using the archive form are stored locally in a back-end Digital Asset Management System, and the data are categorised by entity type.

The local system provides a data store to the community museum digital media archive and a selection of resources from other community museums. Holding resources locally will enable provision of a high-quality web service with bespoke web and mobile applications to address digitization, description, archives and exhibitions. The 3D galleries are made up of 3D artefacts, and virtual tours are made up of photospheres, and in addition to these, other entity types include audio, flat (2D and 3D video), flat (2D and 3D) images, and museums which represent the top level entity. Web and app services will enable museums and their communities to use the phones and computers they already have and are familiar with to communicate with digital museum. An interface also connects the museum to the Internet and enables museums to upload and download resources to a global data store. Synchronization between local and global archives will enable global reach to be achieved, but not require high speed wide area connectivity.

6 Global Access, Archives, Maps and Galleries

A map interface will indicate the location of museums participating in the network. Each museum will be represented to an icon that links to digital resources connected with the museum. These resources will include: digital galleries of 3D objects held on social archive sites, virtual tours using 360°technology with embeded interpretation, mobile apps museum web pages, museum wikis and social media. A presentation front end enables the public to consume cultural heritage content that exists in the backend data store. This is improved upon by pairing the presentation front end with a management front end that heritage experts and community members alike can use to easily populate the back end with content. This is manifested in form of a web-based archive form which can be filled to supply information about a new entity, or with which content can be retrieved and edited to modify information about a new entity. The information supplied using the archive form is mapped to the Europeana Data Model (EDM, which builds on the Dublin Core schema) to leverage the literacy and familiarity of heritage practitioners with these schemas, and to improve interoperability with other cataloguing and asset management systems, towards achieving the goal of ease of management. The user experience while using the is enriched by immersive technologies including in-built support for virtual reality headsets while

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undertaking virtual tours or exploring 3D artefacts. The engaging experience is not lost in the absence of virtual reality headsets, as users can still consume the content on mobile (smartphones and tablets) and web platforms.

7 Policy and Deployment

The damaging effects of climate change to cultural heritage have been thoroughly documented and explored by UNESCO and museums across the globe. It is pressing that the causes of climate change are addressed, some combination of International agreements and social movements seems to provide some hope in that direction. In the meantime there is much that can be done to address the effects of climate change on heritage, one aspect of this is strategies for digital preservation.

This paper has focussed on community museums as they contain heritage that is valuable to the communities they represent, through their communities have untapped resources that could be mobilised for preservation and are particularly vulnerable to the effects of climate change. We propose a policy which considers the severity of the threat of climate change and the vulnerability of community museums to select museums for a program of developing digital museums for preservation in localities and connecting these to a global virtual museum. Starting with a few case studies this program will expand to a global network involving hundreds of museums. In each case training and workshops will be provided to empower communities to develop their museums.

8 Conclusion

This paper has outlined the case for designing developing and deploying a digital museum that enables community museums to digitise and preserve their cultural heritage in the face of climate change and other threats. It is motivated by the observation that developments in digital literacies, mobile technologies and media mean it is possible for community museums to create archive, present and share engaging exhibits that digitally preserve the current state of their collections.

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